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ORIGINAL ARTICLE

Parametric optimization for floating drum anaerobic bio-digester using Response Surface Methodology and Artificial Neural Network

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KEYWORDS

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Temperature;
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RSM;
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Abstract The main purpose of this study to increase the optimal conditions for biogas yield from anaerobic digestion of agricultural waste (Rice Straw) using Response Surface Methodology (RSM) and Artificial Neural Network (ANN). In the development of predictive models temperature, pH, substrate concentration and agitation time are conceived as model variables. The experimental results show that the liner model terms of temperature, substrate concentration and pH, agitation time have significance of interactive effects ($p < 0.05$). The results manifest that the optimum process parameters affected on biogas yield increase from the ANN model when compared to RSM model. The ANN model indicates that it is much more accurate and reckons the values of maximum biogas yield when compared to RSM model.

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1. Introduction

Nowadays, due to population explosion the increase in energy consumption, a substantial rise in the use of fossil fuel, its cost and green house effects and rare utility of natural energy resources have kindled huge public awareness toward global energy production [1]. Major factors such as environmental conditions, global warming and sustainable energy growth are prompting the scientists to explore possibilities of producing low cost, and environmental eco-friendly alternative energy resources [2]. The unified bio-refinery is a formation, where biomass is commuted into fuels and biogas of high energy value with minimal waste generation [3]. The anaerobic digestion is one of the biological processes. In this process organic waste materials are converted into useful biogas [4].

The biogas is a type of biofuel. It is produced in aerobic and anaerobic manner of organic materials [5].

Generally biogas generation is mainly based on the growth of methanogenesis bacteria and micro organisms' presence in the bio-wastes. The growth of methanogenesis bacteria mainly depends upon different operating parameters such as pH value, temperature (T) and organic loading rate (OLR), hydro retention time (HRT) and design of the digester [6]. It is one of the complex processes with a number of synergistic controlling factors. At agricultural and industrial level, even a small improvement in the process, gives greater yields which may be commercially successful.

The biogas optimization process is a major field of research in the area of agricultural and industrial bio technology [7]. A

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Nomenclature

T	temperature, °C
T_j	predicted biogas from observation
P	total number of data observations
O_j	experimental output from observation
R^2	absolute fraction of variance (or) correlation coefficient
CH_4	methane
CO_2	carbon di oxide
NH_3	ammonia
RSM	Response Surface Methodology
ANN	Artificial Neural Network
OLR	organic loading rate
HRT	hydro retention time
CCD	Central Composite Design
CV	coefficient of variance
MAE	mean absolute error
SC	substrate concentration
AT	agitation time
ANNOVA	analysis of variance
BPNN	Back Propagation Neural Network

large amount of solid waste is produced each year in India. Agricultural and industrial activities are the main sources of these solid wastes. Among agricultural wastes, rice straw is a major waste available in Tamil Nadu. Rice straw is rich in protein, glucose and starch. Rice straw has a high content of lignocellulosic fiber (6–26% of the mass of waste material) [8].

The previous study, incurs that the optimal pH (acid production) ranges with various substrate concentrations for anaerobic digestion producing biogas 6.8–7.4 [9]. Basically, the growth of methanogen bacteria can be highly reduced when the pH range is less than 6.6 [10]. The Carbon/Nitrogen ratio of biogas production from rice straw is found the best ratio between 20:1 and 30:1 [11]. The Response Surface Methodology is one of the optimizing tools for analyzing several independent factors in response to expected dependent variables, because it integrates mathematical and statistical techniques [12]. The recent studies indicate that a response surface method was explicated degradation for computing the CH_4 yield for glucose degradation by a combined continuous and batch anaerobic mesophilic range under different experimental conditions [13]. The ANN is suitable for growing of bioprocess models and ANN models are purely data-based. The data virtually used in ANN architecture are multilayered and approximates nonlinear relationships exiting

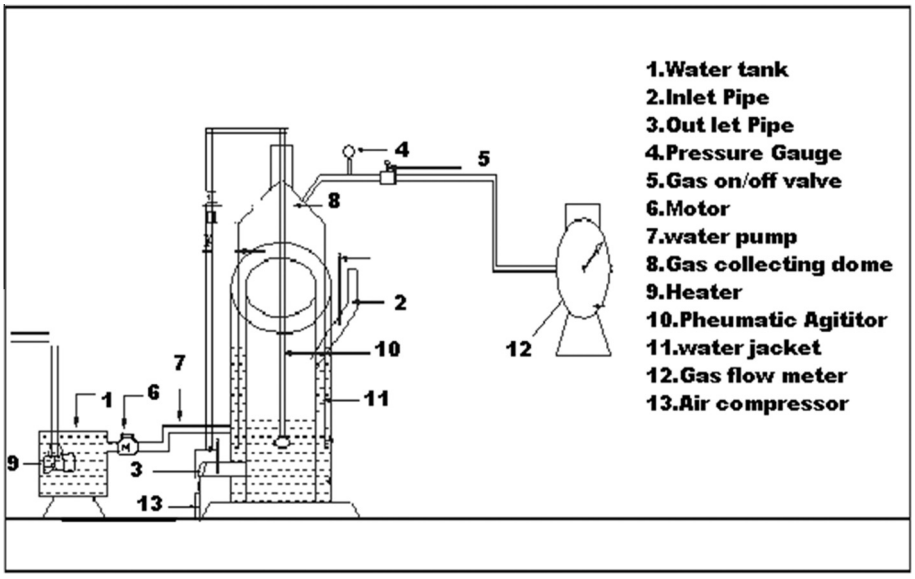

Figure 1 Schematic view of the experimental setup.

Table 1 Levels of factors and variables used for optimization.

Factors	Name	Range of variables (coded)				
		−2	−1	0	+1	+2
A	T (°C)	40	45	50	55	60
B	pH value	6.8	7.0	7.2	7.4	7.6
C	SC (kg)	90	100	110	120	130
D	AT (s)	2	4	6	8	10

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